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CATs Californians for Alternatives to Toxics
315 P Street Eureka, CA 95501 USA
phone (707)445-5100 fax (707)445-5151
e-mail: cats@alternatives2toxics.org web site:
http://www.alternatives2toxics.org

November 19, 2002

To: James Bond
National Marine Fisheries Service
1655 Heindon Road
Arcata, CA. 95521

Re: Simpson Resource Company, California Timberlands Division Aquatic Habitat Conservation Plan (HCP) and Candidate Conservation with Agreement Assurances (CCAA) Draft Environmental Impact Statement (DEIS)

Dear Sirs,

Californians for Alternatives to Toxics (CATs) is a public interest organization concerned about the use of and alternatives to pesticides in California. The activities planned for the SimpsonAquatic Habitat Conservation Plan (AHCP) and Candidate Conservation with Agreement Assurances (CCAA) and analyzed in the Draft Environmental Impact Statement (DEIS) are of particular concern to our members who have an abiding interest in the effect of herbicides and other pesticides in the forest environment.

Simpson states that it did not seek coverage of vegetation control with herbicides as part of the Permits. According to Pesticide Use Reports filed with the Humboldt County Agricultue Commissioner in 2001, Simpson used 3,147 gallons and 400 pounds of pesticides in 2001, including 3 pounds of gopher bait. Does Simpson intend to use gopher bait again? This is a rodenticide, not an herbicide and thus must be included in any future permit applications and attendent assessments and analysis that have to do with herbicides.

Due to a recent Consent Decree, the U. S. Environmental Protection Agencywillbegin conducting consultations about the herbicides most used by Simpson and relating to the impacts of the herbicides in forestry operations to several of the listed endangered species in the areas of Simpson's operations. See attached Consent Decree Californians for Alternatives to Toxics, The Environmental Protection Information Center inc., and The Humboldt Watershed Council, Plaintiffs, vs. Environmental Protection Agency, Christine T. Whitman, Defendants. Case No. C00-3150 CW for further details (http://www.alternatives2toxics.org/epa.htm. Simpson and the National Marine Fisheries Service must begin the permitting process when the related determinations are completed and, at latest, when consultations are completed.

In describing the current environmental conditions, the probability of contamination with pentachlorophenol at any of Simpson's mills, in particular the mill at Big Lagoon/Redwood Creek, which likely has contaminated the Big Lagoon, was not taken into consideration, nor were the

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probability of contamination with any number of other chemicals, particularly the petroleum hydrocarbons, where the aquatic condition may be affected. We are also aware of a botched clean up of various hydrocarbons at the Corbell Mill that effects Mad River. Contaminated sites must be identified, characterized and analyzed because these sites can have a very significant impact on the base environmental condition and add further stress to the environment and endangered species that must be considered. Because this critical information is missing, the DEIS fails and must be rewritten.

Sincerely,

Patricia M Clary

Patricia M. Clary
Executive Director

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2001 PUR

Simpson Timber Co.

Pesticide Amounts:

- Aatrex = 161.5 LB, 30 oz, 332 GA
  2,584 oz. 2,614 oz.
- Oust = 3,436.5 oz, 21 GA
- Garlon 4 = 1,779 GA, 52 oz,
  1 lb = 16 oz. 68 oz
- Roundup = 26.5 GA, 128 oz.
- Transline = 72 oz.
- Hasten = 5.8 GA, 28 oz.
- 2,4-D = 445 GA
- Herbimax = 342 GA
- Garlon 3A = 8 GA
- Activator 90 = 88 GA
- R-11 = .5 GA

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- Gopher Bait = 3 LB => 48 oz.
- \+ • Arsenal = 26 GA

3,075 GA, 6,394.5 oz

Row:

- Drexel = 5 GA
- Round-up = 21.75 GA
- Garlon 4 = 11 GA
- Activator 90 = 11.5 GA
- Roundup Pro = 12.75 GA
- Glypro = 9 GA
- \+ • Transline = 1 GA

72 GA

Grand total + ROW => $\boxed{\text{3,147 GA, 400 lbs.}}$

Letter - G8. Signatory -Salmon Forever.

<u>Response to Comment G8-1</u>

Receipt of the report acknowledged, thank you. The Plan, consistent with regulations governing the Services' approval of ITP applications, includes a conservation plan that is based on the best scientific and commercial data available. Literature relied upon in drafting the Plan is identified in AHCP/CCAA Section 9. The Plan includes measures relating to the potential for slope failure in the Plan Area.

Licensed foresters, California Registered Geologists and other resource professionals will assist with planning operations in the Plan Area, including implementation of the Operating Conservation Plan However, determinations of "significance" and "risk of take" were not within the applicant's discretion but were reviewed by the Services. The Plan sets forth a variety of measures to address various potential impacts, such as those from slope failure. The Services believe that the Plan as a whole meets the HCP/CCAA approval criteria (Master Response 8) and that the Plan will achieve its purposes.

In any case, IA paragraph 8.5 memorializes the Services' authority to conduct inspections and monitoring in connection with the Permits in accordance with Federal regulations. Further, there will be annual reviews for the first five years of the Plan. In the second and fourth years, the annual meeting will be followed with a field review of implemented conservation measures to allow technical evaluation of conservation measure implementation. AHCP/CCAA Sections 6.2.7.4, 6.3.7; IA paragraph 8.5. Biennial reports notwithstanding, the Services may request any additional available information reasonably related to implementation of the

ID: NOV 19'02 15:14 No.002 P.01

Amedee Brickley or Susan Neel-Goodsir
This report is to be
Attached to Comments
of Harriet Hill, Salmon
Forever and Jesse Noell for Simpson HCP/SYP
— thanks Jesse Noell

Susan Neel-Goodsir — fax 822-8411

RECEIVED
NOV 19 2002
Nat'l Marine Fisheries SVC
Arcata, CA

To: FWS, NMFS, CDF
RE: Simpson HCP/SYP
Date: Nov 19, 2002

"Preliminary Report"

G8-1

To whom it may concern,

Observational methods used to determine the significance of changes in slope failure hazard associated w/ the plan SYP are inadequate. The attached report provides best available information for failure hazard for similar soils to those found on Simpson lands. This report documents increased hazard resulting from vegetation removal/soil pore pressure changes/road side cast, fill, and cut related failures.

Furthermore, a geotech who ~~[illegible]~~ determines "significance" using a poorly defined or undefined parameters, provides an arbitrary and capricious "determination of significance" to the wildlife biologist or fisheries professional who must determine what level of "risk" or "take" the species can tolerate. Finally, it is unprofessional conduct for the geotech to opine on "risk" whether that risk be to beneficial use of water, hydrology, or species. Sincerely Jesse Noell

Plan in Green Diamond's possession or control, or in the possession or control of any of its affiliates, contractors or other third parties covered by the Permits for the purpose of assessing whether the terms and conditions of the Permits and the Plan are being fully implemented. Green Diamond is required to use its "best efforts" to provide any such information within 30 days of the request (IA paragraph 8.3). Professional technical staff of the Services and of Green Diamond will work together to evaluate effects associated with Plan implementation in the Plan Area.

See Master Response 13 regarding the role of foresters and practice of geology. As discussed there, any covered activities that involve geological issues and require the expertise of an RG would need to be carried out by, or occur under the supervision of, an RG as required by California law. See Business and Professions Code section 7800 *et seq*... The Services believe that the Plan has adequate measures to minimize and mitigate impacts to the covered species to the maximum extent practicable. See AHCP/CCAA Section 6.2.2 and 6.3.2 for a discussion of the measures.

MANAGEMENT-RELATED LANDSLIDES ON PACIFIC LUMBER LANDS, HUMBOLDT CO., CA: A GEOTECHNICAL PERSPECTIVE

NOVEMBER 2001

Prepared for:

Scotia Pacific Company LLC
P.O. Box 712
Scotia, CA 95565

By:

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Wayne Adams, CEG (11/22/02)
HartCrowser
1910 Fairview Avenue
Seattle, WA 98102-3699

MANAGEMENT-RELATED LANDSLIDES ON PACIFIC LUMBER LANDS, HUMBOLDT CO., CA: A GEOTECHNICAL PERSPECTIVE

NOVEMBER 2001

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Purpose

The purpose of this report is to document the findings and implications of landslide and road cut-slope surveys conducted in 1999 and 2000 on Pacific Lumber lands in the Freshwater, Elk River, Van Duzen, Lower Eel, and Eel Delta watersheds; Humboldt County, California. It must be noted that there are many landslide features mapped in these watersheds which may be active or dormant in nature. The recognition of these potentially-unstable landforms is important and proper precautions must be taken in dealing with them. However, unless reactivated by land-management activities, the focus of this survey was not concentrated on these features but on those landslides which were obviously related directly to land management. In that respect, this landslide survey was not intended to be a complete landslide inventory only to provide insight on how to identify and quantify the mode of management-related slope failures and the factors contributing to those failures. Soil-mechanics-based stability analysis methods were used in this quantification process. The effects of management activities such as road cut-and-fill slope construction, quarry-site development, and tree removal can-be-and-were modeled in these stability analyses. The end result is a compilation of data which should provide a better understanding of the effects of land management on the stability of slopes. It is intended that this initial data will provide the framework and starting point for a dynamic geotechnical database which will aid land managers in the prevention and/or mitigation of future management-related landslides. Suggestions and guidelines for geotechnical specialists for use in future geotechnical investigation and analysis are included which will facilitate the evaluation of management activities on landsliding potential.

Approach

This work was completed independent of the field work for the mass-wasting (slope stability) part of the analysis of these various watersheds. However, to be of maximum value to management, the data gathered for the watershed analysis should also function to support subsequent levels of management (timber harvest planning and development). This required an understanding and quantification of management-related landslides and similar data from actual landslides which compliments and supports the watershed data. This study was intended to

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provide that direct link to the watershed data by using the same soil-mechanics-based stability
analysis methods used to analyze existing management-related landslides. These methods of
stability analysis are proven methods used universally by geotechnical engineers to quantify and
evaluate existing soil, rock, and groundwater conditions for the design and construction of stable
slopes or landslide-mitigation structures. In their simplest form, these stability analysis methods
are applicable to the evaluation of slopes of watershed proportion. Much effort is being exercised
in watershed analysis and the types of information and data being gathered can be useful beyond
this level of management decision making if it is put into a geotechnical format. The watershed
analysis should be only the beginning of the stability analysis and evaluation process and not a
"dead-end". This approach is applicable to all levels of planning and development and is facilitated
by a geotechnical database which becomes more accurate with use and feedback.

Since only management-related landslides were surveyed, it became obvious in review that
the findings were not purely geotechnical but could be of value directly to land managers. With
that in mind, this report is directed at two audiences: the land manager who makes the risk-vs-
consequence decisions for the management of landforms of marginal stability and for the
geotechnical specialist who can provide the problem definition and evaluation to support that
decision-making process. An attempt has been made to separate the body of this report into less-
technical paragraphs in which a land manager unfamiliar with soil mechanics can review the
contents without getting bogged down with technical jargon. The more-technical material
directed at the geotechnical specialist with a soil-mechanics background is included in the later
parts of the report, primarily in the Appendices. It must be noted that this is not a soil-mechanics
primer and this technical material may not be of interest to the physical geologist or civil engineer
who does not have a geotechnical background or geotechnical experience.

Intended Use - By the Land Manager

To land managers, the material in this report is intended to accomplish two things:

* to provide a better understanding of the importance of geotechnical input
(founded on a good database) to the long-term decision-making process and

* to point out some implications for future management activities which can be
concluded from the management-related landslide and road cut-slope surveys.

The primary purpose of a geotechnical database (and the only good reason to have one) is
to provide the input for stability analysis for the evaluation of landslide potential from land-
management activities and to aid the management decision-making process. Furthermore, since
these land-management decisions must be made at more than one level, a dynamic database must
be functional enough to support decisions at all levels.

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Decisions on at least three broad levels of land-management must be supported:

Level I - Resource Allocation. This is the broad watershed analysis level. At this level, decisions are often made as to whether-or-not to manage or how intense the management activity can be in relationship to landslide risk and consequence. However, at this level, the data available to support such decisions is often not adequate and these critical decisions should not be finalized without further evaluation at the next level. Therefore, the most significant attribute of this level of analysis is to locate those geomorphic landforms which have the greatest risk and/or consequence and which should require the most attention in the next level.

Level II - Resource Planning. This is the timber harvest planning level. At this level, site-specific data is used to better evaluate the potential for landsliding resulting from land-management activities. Level I data can be field evaluated and additional data gathered as required for the Level II analysis. This data is used to update and improve the database. During this Level II reconnaissance, the most critical locations on the landforms can be identified for evaluation at the next level.

Level III - Resource Development. This is the timber-harvest and road-construction level. At this level, specific slopes are evaluated and specific designs are developed to prevent or mitigate a specific landslide which might result from land-management activities. The data gathered at this level is the most accurate for upgrading the database for future analysis.

It must be recognized that there are other methods in common use for rating the sensitivity of landforms to landsliding potential which do not require a geotechnical database. These methods are often less expensive to apply and rely primarily on the identification and evaluation of physical site factors. These methods are used primarily at Level I and unfortunately, if misapplied, usually result in a "manage-or-don't-manage" decision. Also, particularly at Level I, these methods tend to "dead-end" since they do not lend themselves to applications at the subsequent levels of management decision-making. The reason for this is that these other methods are not based on a sound mechanical model which considers all of the variables in the proper proportion. The "what-happens-if-we-manage-this-way" type of questions that a land manager should ask can only be evaluated by modeling the anticipated changes which could be caused by the management activity in a relative stability analysis. In this type of analysis, the evaluation of the consequences of slope failure is as important as the evaluation of the risk in forming of the management decision. The consequences ("so-what-if-it-fails" questions) can be addressed in relative proportion to the risk (potential for irreversible watershed or water-quality damage or land productivity). Such things as loss in root strength, increase in groundwater concentration, changes in slope geometry (road cut-and-fill slope construction), etc. can be modeled and evaluated in a realistic soil-mechanics-based stability analysis. To properly evaluate management alternatives, the separation and quantification of all variables is essential.

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Intended Use - By the Geotechnical Specialist

Much of the information in the later part of this report is intended for a geotechnical specialist with a working knowledge of soil mechanics. In addition to a knowledge of the typical mode of failure and suggestions for slope stability analysis of management-related landslides, there is much information on typical soil parametric values which should be of interest and useful in future geotechnical applications. The intent is to provide a geotechnical starting point for slope stability analysis. The initial hypothesis at the beginning of this project was that an experienced geotechnical specialist with a working knowledge of soil mechanics, using simple field observations and soil identifications, should be able to estimate soil shear strength parameters with sufficient accuracy to perform routine stability analysis. Most practical landslide situations do not warrant or cannot support extensive shear strength testing to quantify these parametric values. The information in this report can be used as the basis for a simplified and cost-effect means for estimating workable values for these parameters. This approach has been used throughout the northern Rockies and Pacific Northwest and, based on the findings of this study, it is applicable for Pacific Lumber property as well. This material is only a starting point and is not intended to replace good judgement or relieve the geotechnical specialist of the responsibility for self-calibration and for field verification on a case-by-case basis.

Summary of Surveys & Similar Characteristics of Management-Related Landslides

A total of 128 management-related landslides were surveyed in this study. Most of these were in the Freshwater and Lower Eel Watersheds. A good representation of geomorphic landforms and parent rock formations were included in the area covered. The occurrence of these landslides were probably within the last ten years and perhaps even the last five years judging from the rapid revegetation which makes field identification difficult. Appendix A contains photographs and typical sections of the landslides. Almost all management-related landslides were translational in failure mode (although some may have progressed from a rotational mode into a translational one) in that they were relatively shallow (less than 10 ft. in depth) and extending downslope a considerable distance (usually hundreds of feet) in relation to their lateral extent (usually less than 100 ft.). The surface of sliding and groundwater concentration mechanism was generally exposed directly below the headscarp. The prefailure slidemass material contained very little colluvium (gravity-transported soil and rock deposits) and the failure material was usually residual soil which formed the mantle at the ground surface from the weathering in-situ of the parent rock. This mantle is also the rooted zone where groundwater concentrates at a distinct contact with the lesser-weathered and less-permeable confining surface of the parent rock (see Photos 5 & 6). This condition is the primary reason for the translational nature of the landsliding as groundwater concentrates above the confining surface at the top of the less-weathered and less-permeable parent rock and seepage parallel to this drainage barrier results. Figures 1 and 2 illustrate this condition. As a result, the typical surface of sliding is at the base of the rooted zone which is the maximum depth of soil material of weaker shear strength (usually less than 10 ft. depth of soil mantle involved in the failure mass) and the maximum depth of perched groundwater in this unconfined aquifer. An exception to this generalization was observed in the highly-sheared rock on extremely steep slopes (usually over 80 %) in the Van

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Figure 1. Typical landslide conditions for the Wildcat parent rock formation using road cut-and-fill slope failures to illustrate.

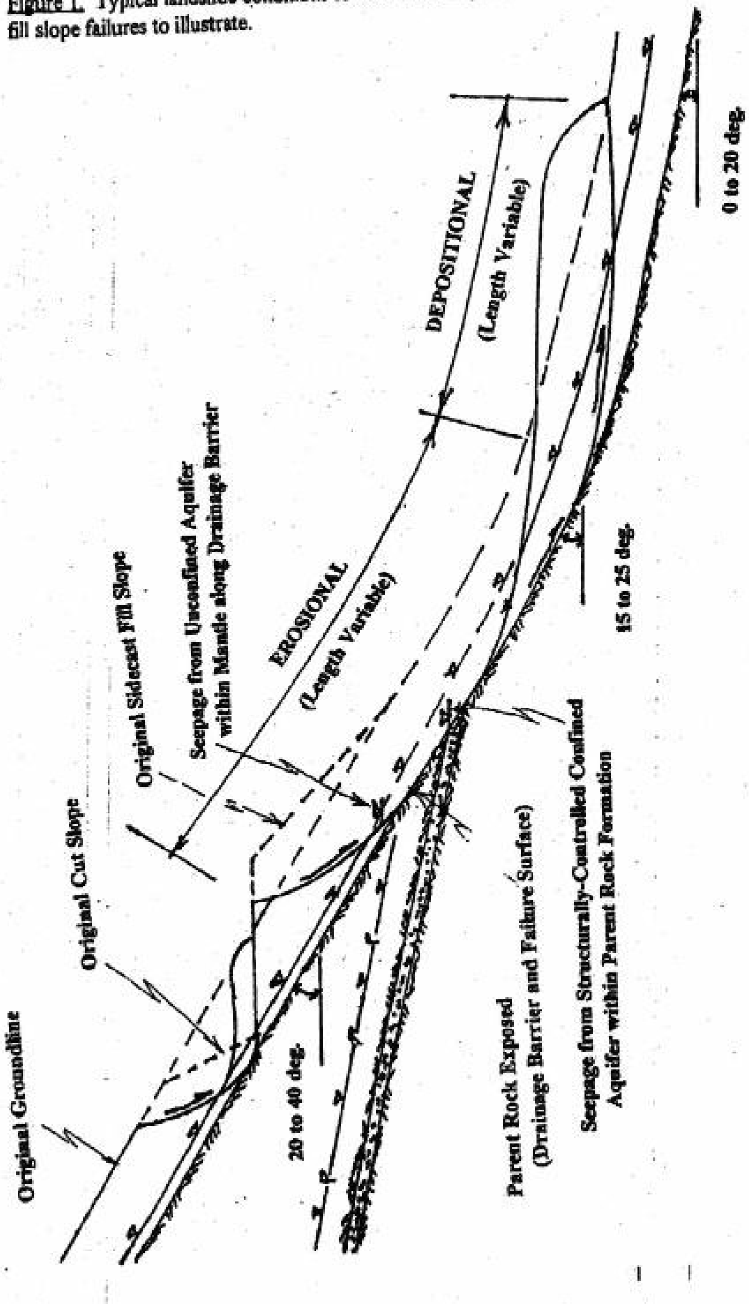

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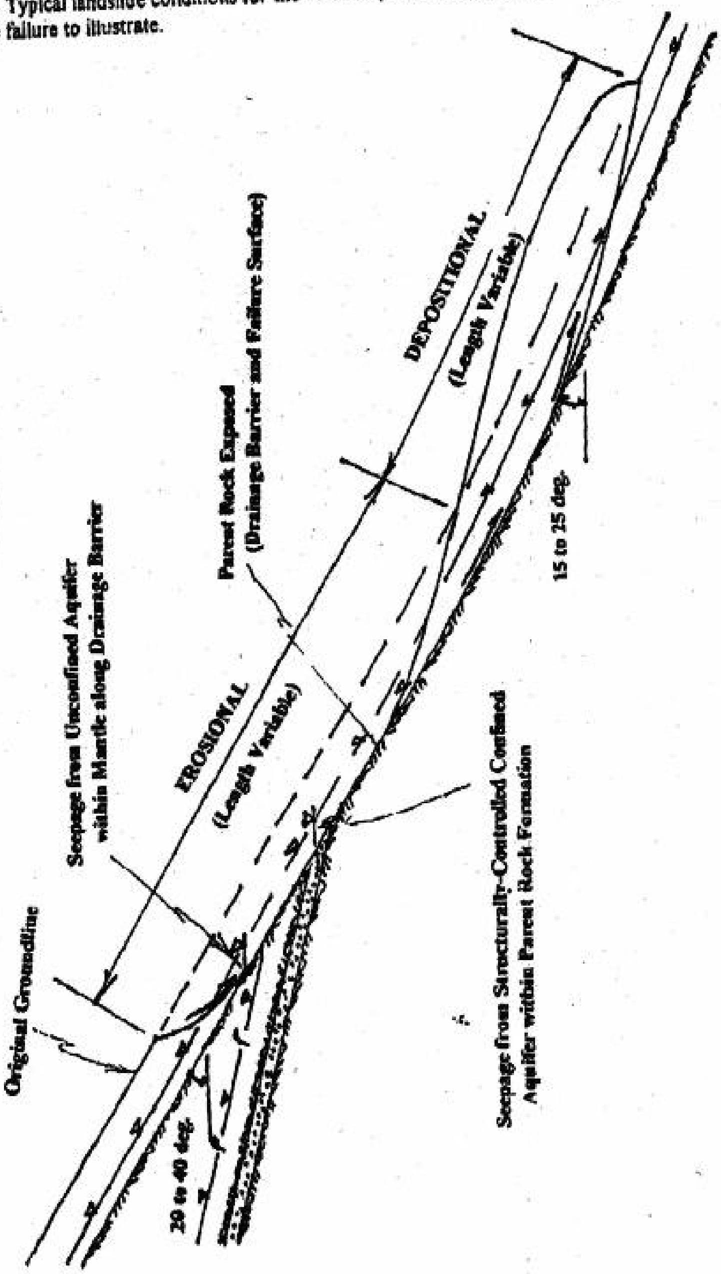
Figure 2. Typical landslide conditions for the Wildcat parent rock formation using timber harvest-unit slope failure to illustrate.



Duzen and Lower Eel Watersheds where landslides often had two distinct failure surfaces: one at the base of the rooted zone and a deeper translational surface in the sheared rock. At these sites, the total depth of the failed section was up to 20 ft. deep and probably involved a second unconfined groundwater aquifer perched at the base of the sheared rock (see Photos 23 and 24 and Figure 3).

An additional source of groundwater for the mantle originates from structurally-controlled confined aquifers within the parent rock (drainage barriers of less-permeable material both above and below the aquifer) in fracture zones (Photos 7 and 8) or sand layers (Photos 9 and 10). Photos 20 through 22 and Figures 1 and 2 show the relative physical relationship between these two aquifers on the slope. The quantity of groundwater in the deeper confined aquifer no doubt varies in response to seasonal precipitation changes as does the unconfined aquifer in the mantle but at significantly different response times, seepage velocities, and drainout times due to the differences in aquifer characteristics of the two (permeability, positions on the slope, groundwater flow paths, etc.). Usually there is little evidence at the ground surface above the subsurface seepage zones (such as water-loving vegetation) which would help to identify these location in the field before failure or exposure in a road cut slope.

The overall geomorphic shape of the ground surface and position on the slope were also determined to be a poor indicator of concentrated groundwater. Many landslides were found to originate as a result of seepage near ridge tops and on planar surfaces (Photos 14, 18, and 19) with only a minor concave shape developing as a result of the failure. The lack of widespread deep colluvial soils and/or the structurally-controlled seepage emanating from the parent rock appears to be the primary reasons for this. The seepage from these confined aquifers is also more continuous late into the year than the seepage which originates from the unconfined ("perched") aquifer in the surface residual mantle. This is probably due to the slower seepage velocities and drainout time of the structurally-controlled aquifers. Seepage from these deeper aquifers is probably the primary source of late-season streamflow long after the unconfined aquifers in the soil mantle no longer contain any free water for seepage.

Appendix B contains a summary spreadsheet of the landslides. The spreadsheet contains the stability analysis used to analyze the failure, the management activity that the failure was related to, the parent rock unit, the average translational conditions of the failure, and the parametric values used in the analysis to model the failure conditions. As shown in Appendix B, about 90 % of the landslides were road-related and most of those were the failure of sidecast-fill slopes. The survey may be somewhat biased toward road-related failures since roads were used to access the watersheds. However, every effort was made to survey the cutting units accessed by those roads and to include the slope failures within the cutting units that were not directly adjacent to the roads. Map and GPS locations of the landslides summarized in Appendix B are available from HartCrowser (Fortuna office).

In addition to the landslides, 195 existing road cut slopes were measured. The spreadsheet at the end of Appendix B summarizes the results arranged according to the textural categories used in the landslide study. The data from this cut-slope survey were used as part of the parametric value determination and to provide information for future road design.

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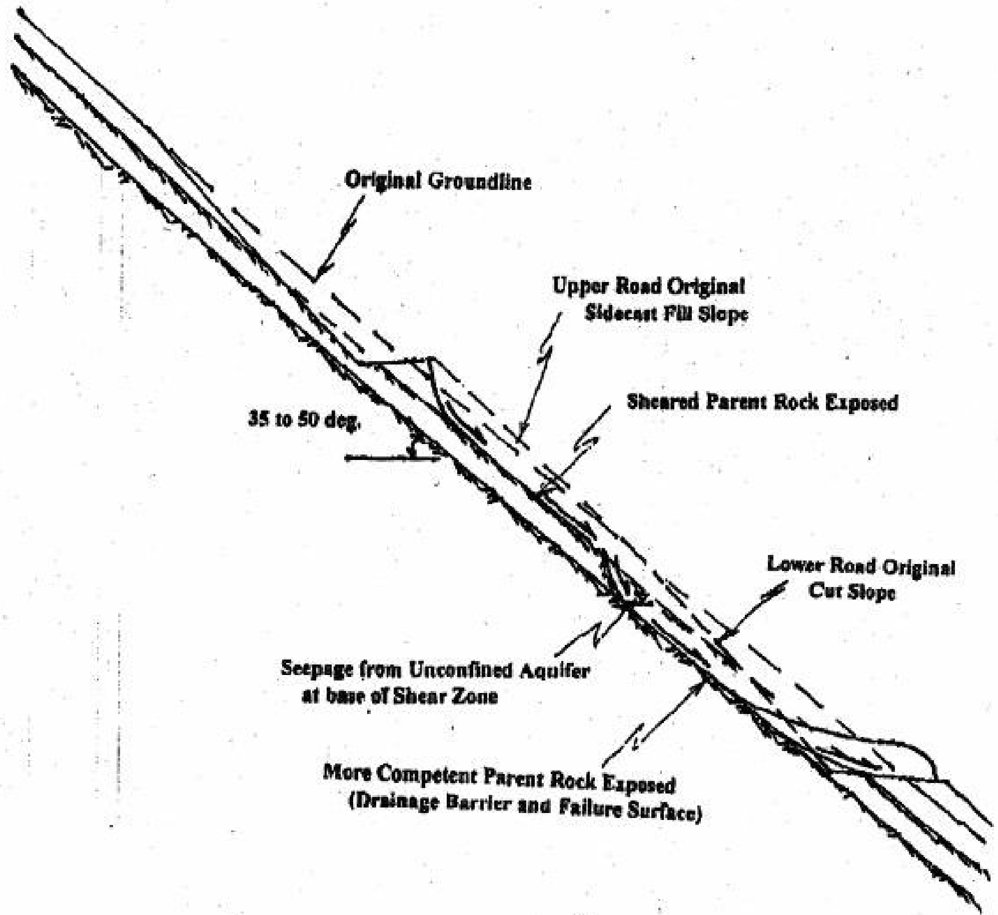
Figure 3. Typical compound fill-slope above and cut-slope below failure which extends through the mantle soil into highly-fracture (shear zone) bedrock. Most prevalent in the Franciscan and Yager parent rock formations of relatively high shear strength.



Land Management - Road Design

As shown in Appendix B, the majority of management-related landslides surveyed were road-related and most resulted from the construction of sidecast-fill slopes. Figures 1 and 3 illustrate the common road cut and fill slope failures. A stability analysis of the typical site conditions in Figure 1 is summarized in Appendix C. The results of this stability analysis present a better understanding of how the road affects the stability of the slope. The results suggest that the failures (especially the sidecast-fill slopes) are most likely to have been progressive:

* starting as a shallow rotational arc failure as a result of groundwater concentration at the base of the rooted zone and once mobilized,

*progressing into a translational failure of the entire soil mantle failing along the base of the rooted zone (the confining surface for the groundwater).

Failure of the translational section extends downslope in an erosional mode (entire depth of soil mantle mobilized) to a position on the slope where the slope becomes more gentle and erosion stops and deposition of the slide debris begins. This is illustrated in Figure 1. In the deposition zone the slide debris is deposited over the existing soil mantle on the more stable slope. The degree of slope where erosional stops and deposition begins is a function of the shear strength of the soil and is predictable.

Some of the results of the landslide survey in Appendix B have management implications applicable to road design and construction. For example, the average natural slope at most road-related landslide sites was about 29 deg. (55%). Since most of these slope failures were sidecast fills, it would be prudent to limit or engineer fill construction on slopes steeper than 55 percent. Also, cut slopes constructed on natural slopes steeper than 55 percent are less likely to progress into translational failures. In the range of natural slopes from 55 to 80 percent, cut slope failures can be expected to be local rotational arc in failure mode which cause significantly less watershed damage than translational failures and can usually be mitigated by engineering design.

The results of the existing cut slope survey in Appendix B also has some management implications which should be noted. The average existing stable cut slope was about 59 deg. (0.61:1 cut slope ratio) and 15 ft. in vertical height. As illustrated on Figure 4, this cut slope would support a road width of 15 ft. in a full-bench cut on ground slopes up to about 32 deg. (62%). Using the same average parametric values for the soil and a design road width of 15 ft. and a full-bench road template, the stability of cut slopes ranging from 0.50:1 to 1.00:1 in cut slope ratio were analyzed as shown in Appendix C. Figure 4 is the graphical illustration of the following results:

Cut Slope Ratio	Critical Vertical Height (ft.)	Maximum Ground Surface Slope (Full-Bench Cut w/ 15 ft. Road Width)
0.50:1	12.4	31 deg. (60 percent)
0.61:1	15.4	32 deg. (62 percent)
0.75:1	18.8	34 deg. (67 percent)
1.00:1	32.9	35 deg. (70 percent)

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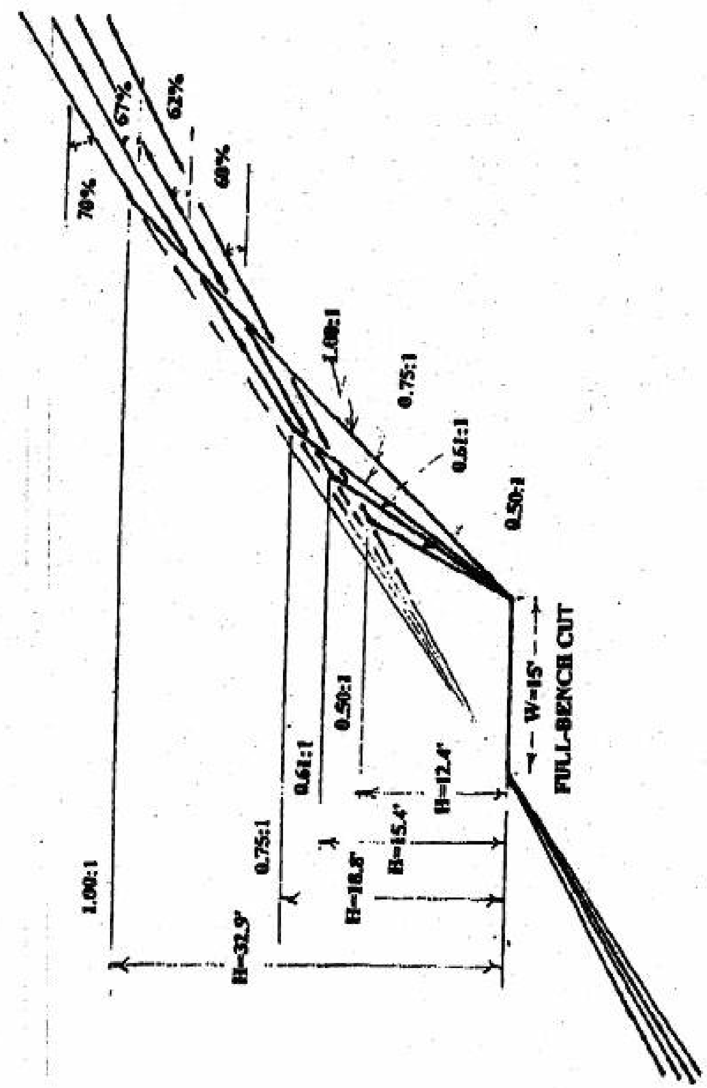
Figure 4. Relationship between the ground-surface slope and the maximum stable out height for a full-bench cut in Wildcat parent rock material.



In addition, field observations (Photos 1,2,3,5, and 6) indicate that existing cut slopes seem to do better from a surface-erosion standpoint if less slope length is exposed which favors the steeper cut slope design where slope stability allows. Combining this information with the observations made for sidecast-fill slopes, the prudent general practice appears to be to use sidecast fills as required on natural ground slopes up to 55 percent with a cut slope of 0.50:1, use a full-bench-cut design template and a road width of 15 ft. with a cut slope ratio of 0.50:1 on natural ground slopes up to 60 percent, a cut slope ratio of 0.75:1 on natural slopes between 60 and 65 percent, and 1.00:1 on slopes between 65 and 70 percent. Exceptions to this generalization will have to be made for soils of extremely weak shear strength and/or site conditions of extreme groundwater concentration. On natural slopes steeper than 70 percent, a thorough geotechnical investigation should be made and an engineered or mechanically-stabilized design may be required for road construction. In addition, when outsloping of the road surface is used to direct the road runoff toward the slope it must be considered as a potential source of groundwater contributing to sidecast-fill-slope failures.

Land Management - Quarry Development

The stability problems associated with quarry development are not so much related to excavation into the relatively hard quarry rock (although this should be addressed in the development of a long-term rehabilitation plan) as they are in the quarry waste embankment constructed on the adjacent natural slopes. Often gentle slopes adjacent to quarry sites are formed by material of very-low shear strength which flanks the hard rock (see Figure 5). Loading by construction of waste embankments causes failure of this weak subsurface material. Although these embankments have relatively small lateral extent as compared to road embankments they are often much larger in vertical height and extensive localized watershed damage can result. Appendix C contains a stability analysis which demonstrates the impact of quarry-waste embankment construction on these weak subsoils. A prudent design practice would be to investigate the subsurface of the "footprint" area where these embankments are to be located for the existence of weak substrata and to prepare this area and design for stability prior to embankment construction.

Land Management - Timber Harvest

Figure 2 illustrates the typical conditions for a failure resulting from timber harvest. Theoretically, three things are usually assumed to happen when trees are removed from a slope:

* a reduction in the surcharge loading of the ground surface,

* a reduction in the root strength of the rooted zone in the soil mantle,

* an increase in the groundwater infiltration from rainfall or snowmelt due to the loss of tree evapotransporation and canopy protection.

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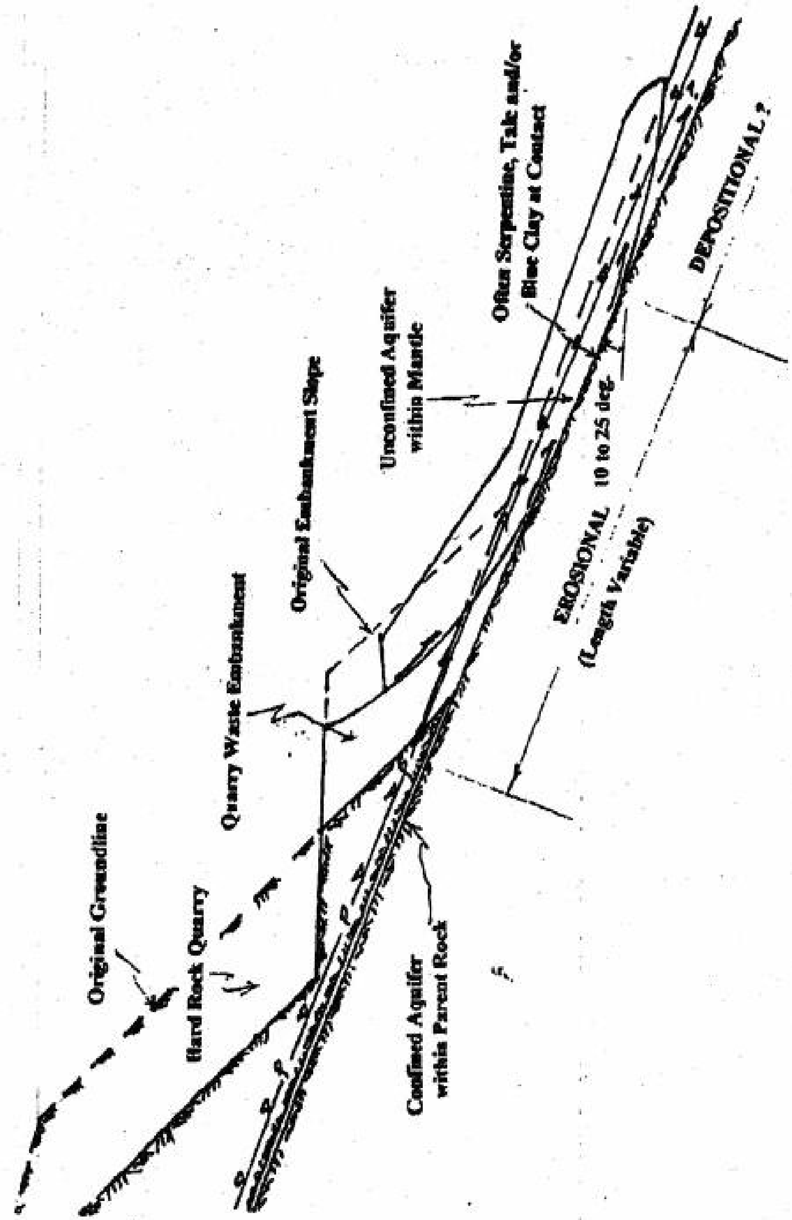
<u>Figure 5.</u> Typical landslide conditions for the Franciscan parent rock formation using a quarry-waste-embankment failure to illustrate.



All three of these can be analyzed in a stability analysis. It can be demonstrated through stability analysis that the reduction in surcharge loading to be expected as a result of tree removal has very little affect on the stability of the slope. This leaves the affects that tree removal has on root strength and groundwater infiltration as the primary concerns in relation to tree removal. There is much theory developed on both of these impacts but very little practical research and supporting data has been documented to quantify the assumptions made. This is unfortunate since unsupported theories have a way of becoming laws in peoples minds if never challenged or tested in an unbiased scientific manner.

The quantification of root strength is compounded since it is very difficult to measure. It is a unique soil-structure interaction problem where not only the soil and root strength properties must be considered, but also the local stress conditions of the soil (active, at-rest, or passive), the degree of soil confinement, and the mode of root failure (shear, tension, or pull-out). Enough field observations have been made to determine that all of these are important factors to consider. In order to properly evaluate, an engineering design (not unlike the design of horizontal reinforcement in mechanically-stabilized embankments or the design of a retaining wall) would have to be made. Roots are considered to add a cohesive strength to the soil mantle which may also be a misnomer since they may also have a frictional contribution which requires a certain overburden pressure to mobilize. What we do know about it has been determined from back analysis of existing landslides considering root strength as a form of cohesive strength and combining it with other forms of cohesive strength such as apparent cohesion from capillary soil moisture and true soil cohesion which the plastic (clayey) soils exhibit. From these back analyses, ranges of total cohesion (of all forms) have been calculated which indicate that the range of quantitative cohesive values which can be linked directly to the effect of roots is relatively small. That is not to say that it is unimportant to consider. Appendix C contains the results of the stability analysis for cutting unit landslides that are tree-removal related. It shows that on extremely steep slopes and shallow soils, a reduction in total cohesive strength of as little as 25 psf can decrease the factor-of-safety-against-failure by 20 percent or more.

The effects of tree removal on groundwater rise in a soil column has also had very little verification with actual measurements. Other than for the results of a few site-specific studies, there are currently no practical universally-applicable methods available to predict with any accuracy the impact of tree removal on this important and most dynamic variable. However, unlike root strength, groundwater rise in response to precipitation can be measured and quantified. Unfortunately in practice, it is seldom done, mostly because long-term continuous monitoring is time consuming and expensive. This type of monitoring is sorely needed and it needs to be done on as many sites as economically feasible. Local site-specific data is the only means to substantiate or refute the controversial assumptions that are currently based on unproven theories. To be of value, long-term monitoring data should be gathered before-and-after tree removal (on the same site) and related to several precipitation events of comparable magnitude. A stability analysis example was used in this report (see Appendix C) to simulate the effects that groundwater rise (which might result from tree removal) would have on the stability of a steep slope. The same cutting-unit landslide conditions that were analyzed for the effects of root strength reduction were analyzed for groundwater rise in response to precipitation. It shows that on the same slope, a similar decrease in the factor-of-safety-against-failure of about 20 percent can occur as result of an increase in groundwater level of about one foot.

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The results of analysis of landslides in cutting units are inherently less conclusive than those for roads but a few observations are warranted. The most prominent conclusion is that the effects of tree removal on the stability of slopes can be analyzed in a realistic manner in respect to the reduction of tree root strength and groundwater rise. However, at this time, there are no practical means to accurately estimate realistic relative values to quantify these two variables. As a result, back analysis must be used for quantification. The results do show that relatively minor changes in root strength and groundwater rise can have a major impact on the stability of steep natural slopes.

Some other considerations need to be factored into the stability analysis of tree removal. Since the roots of redwood trees don't necessarily die when the tree is cut, the reduction in root strength may be minimal and confined to the understory brush. The management implications for root strength reduction is probably more in the site preparation for reforestation and not in the harvest to be sure that burning is not so hot that it actually does kill the roots (which you don't want to do anyway). The evapotransporation also continues from the live roots in the development of new growth. This may be at a lesser rate immediately after the tree is removed and some potential increase in groundwater level should be anticipated until regeneration reaches a certain point in the development of the new tree. Just how much this is and for what duration can not be predicted at this time. Currently, probably the best way to assess the risk/consequences of tree removal is to survey the condition of recently-harvested cutting units with similar site and soil conditions as the planned cutting unit and base judgement on what can be observed within and cumulatively downslope of the recently-harvested units (what can be related directly to tree removal)..

Land Management - Reactivation of Dormant Deep-Seated Landslides

Deep-seated rotational landslide features are prevalent and have been mapped on all of the watersheds surveyed. There is much concern on the effects that management activities (primarily tree removal) might have on reactivating these massive landslide masses. Some of these features may be caused by other factors other than mass-wasting, but regardless of their origin, they must be treated as potentially unstable landslides and investigated accordingly. The question should not be of their existence but of their management implications. The potential for reactivation of dormant deep-seated massive landslides by management activities can be demonstrated through stability analysis. In the previous paragraphs, the potential for creating shallow translational landslides as a result of road construction or tree removal was discussed. If the potential exists for the reactivation of a much larger deep-seated rotational landslide, it should be evaluated and put in perspective to the potential for developing shallow translational slides which are obviously management-related and are quantifiable.

A relative stability analysis of a dormant deep-seated rotational feature is included in Appendix C. A tree removal example similar to the one described earlier is used to compare the potential for creating a shallow translational landslide within the rooted zone soil mantle to the potential for reactivating a much larger deep-seated feature. In that example, a small reduction in total cohesion of the rooted zone and a small increase in groundwater height within the perched unconfined aquifer of this soil mantle was used to simulate the removal of the trees (same as the tree-removal analysis above). A second confined aquifer below the mantle was used to control the deep-seated failure in this example. An initial piezometric groundwater level for this deeper confined aquifer was established to simulate the same preharvest stability condition for the deep-seated failure as for the shallow translational failure at the base of the rooted zone (both having the same factor-of-safety-against-failure for the preharvest condition). To simulate the postharvest conditions, a decrease in total cohesion of 25 psf and a 1 ft. groundwater rise in the shallow aquifer caused about a 20 percent reduction in the factor of safety which would cause the translational failure. To have the same reduction in factor of safety for the deep-seated failure required these conditions in the mantle and an additional increase in groundwater level of 10 ft. in the deeper confined aquifer.

The results are summarized in Appendix C. Some conclusions based on this example are as follows:

* Beginning with about the same level of stability, the likelihood of a translational failure along the drainage barrier at the base of the soil mantle through a small decrease in root strength or increase in groundwater level in the perched aquifer within the mantle is very great. However, these near-surface changes in the mantle had relatively no affect on the deep-seated failure due to the relatively small portion of the deep-seated failure surface which lies within it.

* It would require a 10 ft. rise in the piezometric groundwater surface of a deeper confined aquifer to have the same unstabilizing affect on the deep-seated failure as the 1 ft. of groundwater rise in the upper unconfined aquifer does on the shallow translational failure within the soil mantle. Both failure modes are possible, but the potential for the shallow translational failure is much greater. The analysis becomes more complicated when you factor in the different characteristics of the two aquifers (the anticipated response time to precipitation infiltration, the relative seepage velocity, and drainout time). The perched aquifer within the soil mantle is probably the more permeable of the two and the first to be recharged by infiltration from the storm event. As such, it is the most dynamic and should have the most rapid response time, the higher seepage velocity, and the more rapid drainout time. The deeper aquifer within the parent rock probably receives its recharge from a location farther from the site and is probably less permeable. This should result in slower response time, slower seepage velocities, and much slower drainout time for the deeper aquifer. What that means is that for the two aquifers, the groundwater level is likely to peak at different times and react differently to storm intensity, storm duration, and antecedent rainfall. Fruit for thought, but about the only conclusion you can come to in comparing the two potential failures is that the high-intensity rainstorm of short duration is more likely to activate the shallow translational landslide and the reactivation of the deep-seated rotational landslide is more likely to occur as a result of less-intense storms of longer duration and antecedent conditions.

Certainly, the results of this relative stability analysis cannot be universally applied to all site conditions. Analysis of different site conditions may well lead to different conclusions and care must be taken to assign realistic parametric values to simulate the management activity. Given that, what has been demonstrated by this example is that a relative stability analysis such as this is possible to put things in perspective for the basis of a risk vs consequences management decision concerning the potential for reactivation of a deep-seated landslide.

Geotechnical - Parent Rock Units and Soil Textural Class

It was determined through the stability analysis of the landslides in this survey that the shear strength of the soils in the failure mass could be predicted by a geotechnical specialist using a general identification of the parent rock units and a field classification of the texture and composition of the residual soils resulting from the degradation of the parent rock. The following description of the parent rock units is intended to help in the interpretation of geologic maps as a starting point for that identification process. Only four broadly-defined rock units are described to include the several geologic formation which exist on Pacific Lumber property. As summarized in Appendix B, these units are further grouped into five categories based on the residual-soil-and/or-sheared-rock textural class identifiable in the field which best categorizes the range of shear strengths to expect.

A total of 130 soil samples were recovered from 109 of the landslides summarized in Appendix B. The sample depths in the exposed scarps, soil textural class, and estimated soil shear strength Group Number, Sn, were documented in the field. The samples were submitted to the ScoPac soils laboratory for the determination of natural moisture content, Unified Soil Class determination, determination of Atterberg limits, and grain size analysis by sieve analysis and hydrometer. Appendix D summarizes the field sample data and the results of the laboratory analysis. Appendix D also contains the results of regression analyses between some index soil properties from the laboratory data and the field-estimated Sn which was estimated in the field. These index properties may be useful in predicting Sn from laboratory data. However, the user is cautioned that there is significant "scatter" in the data and these prediction equations should not be used alone.

The definition of the following rock units are based on origin, rock type, age and stratigraphic position with respect to adjacent rock units. The rock units are broadly defined and generally consistent with existing regional geologic mapping. For geotechnical purposes, regional mapping that delineates 13 geologic formations was simplified to four rock units. Two rock units are defined for the Franciscan Complex and two rock units for the Wildcat Group.

Rock Unit F1 (RUF1). Rock Unit F1 (RUF1) contains the melange sub-units of the Franciscan Complex (co1 and co2 sub-units of McLaughlin et al., 2000). RUF1 is characterized by dark gray, medium to light brown, and green-gray, fine to medium grained sandstone and dark gray argillite. Minor amounts of conglomerate, chert, basalt and limestone are found within RUF1. The more resistant lithologies are moderately- to well-indurated and generally highly-to-pervasively sheared. Pervasive shearing within argillites reduces the rock mass to essentially a scaly clay. The sizes of individual outcrops of resistant lithologies (knockers) within melange can vary greatly from boulder to landform size. Materials within RUF1 range in hardness from soft, remoldable clays to hard, rebound to dent quality fine-to-medium-grained sandstone. Material exposed near the surface are generally highly weathered. Mass attitudes generally have a strong northwest to west-northwest fabric, but can be locally pervasive and be oriented somewhat randomly. Natural separations occur between the soft argillite and hard rock lithologies and along contacts between different lithologies within knockers. The penetratively deformed argillites have a fabric of indurated, lens-shaped rock clasts, commonly within a gray to blue-gray clay matrix. Fractures within competent materials are commonly coated with purple-black manganese oxide and/or orange/red-black iron oxide. Cementation by secondary calcite is common in places where extensive fracturing and faulting of the rock has allowed circulation of mineral-rich fluids. Dissolution of the calcite cement in surface and ground water can create zones of weakness.

The hard rock from RUF1 is often quarry-quality and developed as such. The residual soils can be expected to have shear strengths within the M clay (melange blue-gray clay often containing identifiable talc and/or serpentine), silt/clay, or sandy textural classes as categorized in Appendix B. As summarized in Appendix B, failures in the M clay textural class soils in this survey were found to occur on prefailure natural slopes ranging from 15 to 31 deg. (25 to 60 percent) with an average slope of 22 deg. (40 percent). Failures in the silt/clay textural class were found to occur on prefailure natural slopes ranging from 18 to 41 deg. (30 to 85 percent) with a 31 deg. (60 percent) average slope. For the sandy textural class, failures were found to occur on prefailure natural slopes ranging from 30 to 43 deg. (60 to 95 percent) with a 36 deg. (75 percent) average slope. The typical depth of failure for all classes was the depth of the rooted zone ranging from 1 to 10 ft with about a 5 or 6 ft. average.

Rock Unit F2 (RUF2). Rock Unit F2 (RUF2) consists of relatively intact rock and generally is correlative to the co3 and co 4 sub-units of McLaughlin et al. (2000). We also incorporate rocks of the Yager terrane within RUF2. Rocks of the Yager terrane are nearly indistinguishable from rocks of the Coastal terrane. The Yager terrane is coeval with the Coastal terrane, but was deposited along channels within the continental slope (McLaughlin et al., 2000). We interpret the fine-grained, micaceous sandstone to be characteristic of the sandstone within the Yager. RUF2 contains dark gray, medium to light brown, and green-gray, fine-to-medium-grained sandstone and dark gray argillite. Minor amounts of conglomerate, chert, basalt and limestone are found within RUF2. There are three typical types of deposits within RUF2. Relatively intact sequences of turbidites (submarine basin to shelf slope deposits) and olistostromal (submarine landslide) deposits. While not specifically mapped in the LERW and ERDW, olistostromes may account for much of the apparently randomly-oriented rock masses. Turbidite sequences contain alternating layers of sandstone and argillite, and where relatively continuous rock bodies exist, are correlative to the co 3 and co 4 units of McLaughlin et al. (2000). Distinctly-bedded sequences generally contain tight-to-open folds, flexural slip faults and ramp faulting of more competent sandstone beds along less competent argillite layers. Locally overturned bedding is common. Submarine slope and basin deposits are similar to the turbidite sequences but lack the distinct bedforms of turbidite flows and commonly contain more massive outcrops of sandstone or argillite. Materials within RUF2 range from friable to pit quality. Generally rock material is partly decomposed to stained state but locally can approach completely decomposed in highly fractured, sheared or folded rock masses exposed near the surface. Mass attitudes generally have a strong northwest to west-northwest fabric, but can be locally pervasive and be orientated somewhat randomly. Natural separation occurs along bedding planes within the sandstones and argillites of turbidite sequences, along numerous fractures and along structural weaknesses formed during folding. Fractures are commonly coated with purple-black manganese oxide and/or orange/red-black iron oxide. Cementation by secondary calcite is common in

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places where extensive fracturing and faulting of the rock has allowed circulation of mineral-rich fluids. Dissolution of the calcite cement in surface and ground water can create zones of weakness.

Some quarry-quality rock is available in this rock unit, but is generally of lesser quality that the hard rock of RUF1 since it tends to slack and degrade with time. Residual soils are generally of a coarser texture with more gravel content than RUF1. Shear strengths within the sandy, gravelly, or sheared rock textural classes are summarized in Appendix B. As summarized in Appendix B, failures in the sandy textural class soils in this survey were found to occur on prefailure natural slopes ranging from 30 to 43 deg. (60 to 95 percent) with a 36 deg. (75 percent) average slope. Failures in the gravelly textural class were found to occur on prefailure natural slopes ranging from 30 to 47 deg. (30 to 105 percent) with a 39 deg. (80 percent) average slope. Failures in the sheared rock textural class were generally a compound failure with the sheared rock as a subsoil (second unit) underlying a gravelly soil mantle and were found to occur on natural slopes ranging from 33 to 47 deg. (65 to 95 percent) with a 39 deg. (80 percent) average slope. The typical depth of failures for the sandy and gravelly textural classes (failures confined to the rooted zone) were similar to RUF1 ranging from about 2 to 12 ft with a 5 ft. average depth., On steeper slopes, where failures extended into the sheared-rock textural class subsoil, the total depth (including the mantle depth) ranged from 6 to 22 ft. with an 11 ft. average.

Rock Unit W1 (RUW1). Rock Unit W1 (RUW1) contains the fine-grained members of the Wildcat Group. Specifically, it contains the Rio Dell, Eel River and Pullen Formations and lithologies mapped as undifferentiated. RUW1 contains light-brown to light-gray siltstone to fine sandy siltstone and light-to-dark gray mudstone. Sediments within RUW1 are generally weakly indurated and are in a stained to partially-decomposed state. Lithologies within RUW1 typically consist of interbedded siltstones and mudstones. The bedding planes form latent planes of separation between different lithologies. Separation can also occur along fractures that can locally be common and closely spaced. Most of the formations of the Wildcat Group strike northwest and dip to the north, however, local differences can occur along folds or shear zones.

Residual soil derived from this rock unit should have shear strength in the silt/clay textural class as summarized in Appendix B. Failures in the silt/clay textural class were found to occur on prefailure natural slopes ranging from 18 to 41 deg. (30 to 85 percent) with a 31 deg. (60 percent) average slope. The typical depth of failures for the silt/clay textural class (failures confined to the rooted zone) was similar to the RUF1 and RUF2 rooted zone failures ranging from about 2 to 10 ft with a 5 ft. average depth..

Rock Unit W2 (RUW2). Rock Unit W2 (RUW2) is comprised of the sandy units of the Wildcat Group, The Scotia Bluffs Sandstone and tentatively the Carlotta Formation. RUW2 is characterized by light brown (weathered) to light gray (fresh) fine to medium sandstone and light brown, sandy, pebble to cobble conglomerate. Sandstones of the Wildcat Group are compact, weakly indurated and are generally moldable to crater quality. Bedding within the Wildcat Group is often massive but locally may contain calcium-carbonate-cemented fossil shell stringers and thin muddy interbeds.